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A theory-driven identification and ranking of the critical success factors of sustainable shipping management

ABSTRACT

Sustainable shipping management is arguably the most challenging issue that shipping companies faced for the coming years. Hence, examining the critical success factors of sustainable shipping management is vital. Although previous research mainly focused on the motives and implication of sustainable shipping management, practical research that proposes how sustainable shipping management can be implemented is still lacking. Therefore, this study fills the gap by identifying and ranking the critical success factors of sustainable shipping management with a theory-driven approach. The critical success factors were developed through the theoretical lenses of five organisational theories, namely, stakeholder theory, resource-based view theory, relational-view theory, innovation diffusion theory, and contingency (fit) theory. Based on these theories, this study proposes stakeholders' focus, intra-firm management, inter-firm collaboration, new technology acceptance, and strategic fit as the critical success factors of sustainable shipping management. Further, 20 sub-criteria were identified to operationalise the critical success factors. A survey questionnaire was pretested and then administered to 36 shipping companies in Vietnam. Thereafter, the obtained data was analysed using fuzzy analytic hierarchy process. The findings show that the critical success factors of sustainable shipping management, in descending order of their importance with their respective local weights, are (1) stakeholders' focus (0.298), (2) intra-firm management (0.248), (3) new technology acceptance (0.156), (4) inter-firm collaboration (0.154), and (5) strategic fit (0.143). Moreover, results of this study show that among the sub-criteria of sustainable shipping management, the most important ones are primarily related to monetary resources and tangible infrastructures and equipment. Additionally, sustainable shipping management implementation in shipping companies can be improved by addressing the needs of stakeholders and aligning sustainable shipping management activities with shipping companies' strategies. By evaluating the critical success factors, this study contributes to theory by holistically identifying and reviewing five theoretical frameworks that can enhance sustainable shipping management. This research also contributes to practice by contextualising and operationalising these theories into meaningful criteria and sub-criteria for shipping companies to implement sustainable shipping management. Consequently, it addresses the question of how sustainable shipping management should be implemented to maximise a shipping company's sustainability performance.

Keywords: Critical success factors, Sustainable shipping management, Stakeholder theory, Resource-based view theory, Relation view theory.

1. Introduction

The shipping industry contributes to trade and global economic development by transporting 90% of cargo volume across the world with around 100,000 commercial vessels (UNCTAD, 2017). Meanwhile, the continuous growth in the demand for shipping services has raised stakeholders' concerns (i.e. public, regulators, employees, shareholders, customers, and suppliers) and the shipping industry's impact on the environment and society. In the book "Green ports", Cullinane and Cullinane (2019) pointed out that although shipping has been considered as the least environmentally damaging mode of transport, the absolute quantities of greenhouse gas and other health-damaging pollutions are sizeable. Additionally, these pollutants have negative societal impacts which can affect fisheries and the quality of life of the local communities (Ellram and Murfield, 2017). This has resulted in the implementation and tightening of various regulations such as MARPOL 2020 and Ballast Water Convention which called for a renewed interest towards sustainable shipping management (SSM)..

Sustainable shipping management is defined as addressing the needs of the present without compromising the ability of future generations to meet their own needs (Yuen et al., 2017b). It requires shipping companies to seek a balance in their economic, social, and environmental performances to satisfy a constituent of stakeholders who have a legitimate or silent interest in the company (Cheng et al., 2015). SSM has several connotations such as management of 'the environment', 'safety', 'human rights' (Carter and Jennings, 2002), 'cost-efficiency' (Balland et al., 2015), and 'corporate social responsibility' (Yuen et al., 2017a).

In recent years, existing research on SSM has focused on motives and performance implications. For instance, according to several studies, the motives of shipping companies for implementing SSM include reducing cost, differentiating services, managing risk, enhancing the efficiency of resources and capabilities, responding to laws and regulations, such as the IMO 2020 Sulphur Cap, improving employee's job satisfaction, strengthening relationships with partners or communities, and improving customers' loyalty and financial performance (Balci et al., 2018b;

Lam and Lim, 2016). Essentially, Yuen et al. (2017b) argued that for the business case, implementation of SSM must lead to commercial benefits.

However, although present studies have contributed to the body of knowledge regarding why SSM should be implemented (Lirn et al., 2014), only a few studies have investigated the method of its implementation. For this stream of literature, some researchers have focused on optimising operational decisions within a company, such as balancing productivity and the environment by adopting resource conservation principles (Lai et al., 2013). Others have designed a technology selection framework for emission reduction from ships (Ren and Lützen, 2015). Yuen et al. (2016b) showed that the link between SSM and business performance could be strengthened by employing continuous improvement principles. Lun et al. (2016) emphasised SSM with a focus on relationship management as it plays a key role in enhancing stakeholders' satisfaction and building trust and commitment.

Previous studies have introduced several frameworks or principles on how to implement SSM. However, many of these studies have not incorporated theories in their discussion, which leads to a lack of theory-driven research that addresses the question of how SSM can be implemented. Further, most existing studies are scattered, focusing on a single approach to implement SSM. For instance, some of these authors have focused only on intra-firms' management factors (Lai et al., 2013; Ren et al., 2013), whereas others have examined collaborative resources among partners of shipping companies (Govindan et al.,2013). Therefore, there is a lack of holistic assessment of the approaches for implementing SSM. Besides, shipping companies need to understand the relative importance of these SSM approaches or critical success factors (CSFs). To the best knowledge of authors, the literature lacks a study that ranks CSFs of SSM based on their relative importance.

In summary, the main gaps in the field of SSM are lack of comprehensive theory-driven research and CSFs ranking-driven studies that can enhance the success of SSM implementation. To address the aforementioned gaps in the literature, the first objective of this paper is to provide a theoretical identification of the CSFs of SSM by reviewing five main management theories: (1) stakeholder theory, (2) resource-based view (RBV) theory, (3) relational-view theory, (4) innovation diffusion theory, and (5) contingency (fit) theory. In this context, these theories propose 5 main criteria and 20 sub-criteria. Accordingly, the five main criteria are stakeholders' focus,

intra-firm management, inter-firm collaboration, new technology acceptance, and strategic-fit. The second objective is to rank the CSFs of SSM based on their importance rated by the industry practitioners. According to Yuen et al. (2019a), organisational resources of companies are scarce. Especially, among the resources, data sharing and collaboration technologies, such as the Internet of things, artificial intelligence, and quality of services applications, have provided a new insight for enabling sustainable management (Sodhro et al., 2019a; Sodhro et al. 2019b; Sodhro et al. 2019c; Sodhro et al., 2017a). While these recent studies have offered new insights to SSM, the contributions of these studies are mainly unidimensional, focusing on a single aspect of SSM. Additionally, from a resource allocation perspective, studying the CSFs of SSM is essential for shipping companies to prioritise and allocate their resources in their management of sustainability to achieve maximum stakeholder satisfaction or performance utility. Since this study involves the ranking of CSFs, fuzzy analytic hierarchy process (FAHP) has been chosen as the most applicable technique for the analysis of SSM in shipping companies because it employs pairwise comparisons and allows decision-makers to have a better understanding of the relative importance of interacting criteria. Besides, it also allows formulating decision-making criteria in multiple hierarchical levels.

The major contributions of this paper are two-fold. Firstly, this study contributes to theory by reviewing five main management theories, which underpin SSM in order to explain the CSFs of SSM from different perspectives. Furthermore, it enriches the literature by ranking and comparing the relative importance of each theory in association with enhancing the success of SSM implementation. Secondly, this paper also implicates policy formulation on the enhancement of SSM by contextualising the theories into meaningful criteria and sub-criteria of SSM, allocating resources of shipping companies, and ensuring sustainability strategy to be consistent with their overall competitive strategy.

The rest of this paper is organised as follow. Section 2 identifies the CSFs of SSM. Thereafter, Section 3 reviews the principles of FAHP and the methodology application for the purpose of this study. Section 4 examines and ranks the CSFs based on the data collected from shipping companies in Vietnam. Section 5 then presents the discussion of this study. Finally, Section 6 provides discussion and conclusions.

2. Literature review

From reviewing the previous studies, the majority of existing research on SSM has focused on the motives and performance implications. However, only a few studies have investigated how SSM should be implemented. Many of these studies have not incorporated theories in their discussion, which leads to a lack of theory-driven research that addresses the question of how SSM can be implemented. Therefore, there is a lack of a holistic assessment of the approaches for implementing SSM. To address the main gaps of current research, the objectives of this study are to identify and rank the CSFs of SSM. Hence, the current paper proposes five organisational theories of stakeholder, RBV, relational view, innovation diffusion, and contingency (fit) to represent each CSF. Accordingly, these theories are operationalised into stakeholders' focus, intra-firm management, inter-firm collaboration, new technology acceptance, and strategic fit.

2.1 Stakeholder theory

Stakeholder theory indicates that managers should engage in sustainable management because they have a moral obligation to satisfy various constituents who have a legitimate interest (e.g. shareholders, vendors, shippers, and customers) or silent interest (e.g. the environment and community) on a firm (Freeman, 2010). It is commonly used by existing research in analysing companies' motivation for managing sustainability (Yang, 2018). Particularly from the institutional perspective, stakeholders such as shareholders, suppliers, customers, competitors, and the public can exert normative, mimetic, and coercive pressure on firms to manage sustainability (Lai et al., 2013; Vejvar et al., 2017). Such abilities confer power to stakeholders who can affect the performance outcomes of shipping companies. Therefore, this necessitates shipping companies to focus on addressing stakeholders' sustainability needs in addition to their economic performance (Pagell and Shevchenko, 2014).

Shareholders' focus includes managing the expectations of financial investors concerning improving companies' economic performance (i.e. return on investment) and ensuring fair and honest business practices (Giannakopoulou et al., 2016). Specifically, sustainable practices targeted at addressing shareholders' needs include disseminating information about the sustainability involvement of the shipping company, managing dividend policies, providing clear long-term business strategies, and encouraging open communication of business strategies (Parviainen et al., 2018).

Vendors' focus includes managing the expectations of suppliers (e.g. terminal operators or feeder companies) that provide services to shipping companies. These expectations can include ensuring fair trading transactions to achieve joint sustainability standards (Al-Debei and Avison, 2010) and aligning their sustainability and business strategies to find synergies in operations (Yuen et al., 2017a). Further, addressing vendors′ needs can allow shipping companies to enjoy discounts from engaging their services.

Shippers' focus involves managing the expectations of customers, who can be manufacturers or logistics service providers, including service quality regarding reliability, price, security, privacy, and visibility of shipments (Van den Berg and De Langen, 2015). Apart from these considerations, shippers are also evaluating shipping companies′ environmental and social performance. Increasingly, shippers are using sustainability criteria for the award of shipping tenders (Yuen et al., 2016b). Satisfying the sustainability requirements of shippers is noted to result in loyalty which is associated with repurchase intention and positive word of mouth (Shin et al., 2017). Hence, sustainability requirements of shippers should be reflected in the management of sustainability.

Employee's focus refers to managing the expectations of employees in shipping companies that include health and safety at work, opportunities for the development of workers′ skills, wellbeing and satisfaction at work, quality of life, and social equity (Pang and Lu, 2018). Employees become productive at work and committed to the cause of the shipping company when the aforementioned expectations are addressed (Octaviannand et al., 2017). As employees are directly involved in shipping companies′ value creation activities, some research has suggested creating a positive working environment with open, flexible communication and providing an equitable reward and wage system (Freudenreich et al., 2019).

Society's focus represents the expectation of a wide variety of parties, including the environment, communities, governments, and media (Bocken et al., 2013). Although the relationship between the parties and the shipping company is not usually governed by contracts, such relationship is crucial from a strategic management viewpoint because the support from these parties can confer commercial benefits to shipping companies such as garnering local support, improving image and reputation, and remaining competitiveness in the market (Joyce and Paquin, 2016). For instance, maintaining a good social and environmental image through social media

engagement can attract quality candidates to join the shipping company (Yuen et al., 2017a). Further, participating in philanthropical activities may garner support from the government. Consequently, shipping companies may be awarded opportunities to participate in the shipment of national strategic goods or enjoy tax rebates or incentives.

2.2 Resource-based view theory

The RBV originates from the strategic management literature. RBV concerns the efficient usage, bundling, and exploiting the internal resources of a shipping company to achieve a sustainable competitive advantage (Jensen et al., 2016). There are two main categories of resources: tangible and intangible. These categories can be further segmented into four dimensions: physical assets, financial resource, sustainable knowledge, and organisational culture.

Physical assets involve investing in eco-friendly assets such as green buildings and equipment, vessels, and trucks to manage sustainability. The implementation of eco-friendly assets can bring many benefits for shipping companies in three aspects: economic aspect (e.g. improving the efficiency of assets), environmental aspect (e.g. reducing the fuel consumption and pollution index), and social aspect (e.g. improving workplace safety and business practices). For instance, Schinas et al. (2018) found that investment in green ships and related technologies can alleviate shipping companies' pressure to cope with environmental regulations such as on reducing the emission of greenhouse gases and releasing of foreign, invasive species into the ocean because of the exchange of ballast water.

Financial resource refers to financial instruments and capital for implementing SSM. Busby (2019) argued that the investment in new facilities, new technology, or the increase of employee wage and work quality, or even environment integration is underpinned by the availability of financial resources. For instance, the lack of financial resource will prevent shipping companies from improving the environmental performance of their ships and hence, undermine their ability to operate in environmentally sensitive areas or improve the working and living conditions of their seafarers (Progoulaki and Roe, 2011). Therefore, shipping companies should ensure the availability of capital obtained from shareholders or reinvestments from earned profits to manage their sustainable activities.

Sustainable knowledge is considered one of the dynamic capabilities that ensure the coherence between the company's strategies and operations and maintain the shipping companies' competitiveness (Yuen et al., 2019b). Shipping companies' ability to create, assimilate, and apply knowledge is underpinned by the level of training, education, and experience and through obtaining sustainability needs from organising focus group meetings and discussion with stakeholders. Essentially, shipping companies possessing good knowledge on how to implement SSM efficiently and effectively are in a better position to exploit current sustainability processes and explore innovative approaches for the implementation of SSM (Durst and Runar Edvardsson, 2012). For instance, the exploitation of current sustainability processes in shipping companies can include exercising continuous improvement by scanning feedback from stakeholders, responding and integrating their sustainability needs into existing strategies and operation, and evaluating and implementing sustainability improvements (Yuen et al., 2019b). Sustainable shipping exploration refers to the alignment of technical innovations and managerial activities. Some recent technical innovations include the adoption of slow steaming, cold ironing, information communication technology applications, ballast water systems, and ship engines capable of using renewable energy (Yuen et al., 2019b).

Organisational culture refers to ‘a set of values and beliefs that decide the behavioural objective and method of organisation, which shipping companies use to manage employees’ (Sunderland and Denny, 2016). In this context, having a culture whereby all employees are supportive of and committed to sustainability can enhance the implementation of SSM. A culture that is supportive of SSM can be espoused in the vision, mission, goals, and objectives of the shipping company or via communication from the management (Yuen et al., 2016b).

2.3 Relational-view theory

While RBV focuses on developing resources within a company to manage sustainability, the relational-view theory points out that SSM can be improved by strengthening inter-firm relationships and creating inter-firm resources, which are difficult to imitate by competitors (Dyer et al., 2018). These resources can be classified into inter-firm relationship management, inter-firm knowledge sharing, complementary resources and capabilities, and effective governance mechanisms.

Inter-firm relationship management refers to creating informal safeguards that are held jointly by the shipping company and its core business partners (Herremans et al., 2016). The development of these safeguards opens possibilities for shipping companies to strengthen competitive advantage effectively by creating complex inter-firm ties (Child et al., 2019). Additionally, the development also attracts more participation and commitment of the partners and builds their trust in shipping companies' commitment to sustainability objectives, which may enhance SSM. For instance, Yuen et al. (2018b) pointed out that a high level of trust between shipping companies and their partners can reduce transaction cost arising from negotiating, managing, and enforcing sustainability-related goals and requirements, and encourage the sharing of information to achieve sustainability objectives.

Inter-firm knowledge sharing refers to the extent to which the knowledge is shared and combined among partners (Dyer et al., 2018). In this study, the shared knowledge can include explicit sustainability knowledge such as sustainability information from database and reports and implicit sustainability knowledge embedded in the practices and skills of employees (Cross et al., 2001). Information sharing of sustainability information is considered a prerequisite for effective SSM (Chandio et al., 2014; Muzammal et al., 2020). For instance, Lee and Nam (2017) revealed the advantages of sustainability information sharing such as time and money savings and service quality improvement. Therefore, SSM can be improved by sharing sustainability information through organising regular inter-firm conferences, meetings, and workshops to exchange best practices and ideas.

Complementary resources and capabilities refer to the pooling and sharing of financial, equipment, and labour resources to create distinctive inter-firm resources to manage sustainability. For instance, shipping companies and port operators can pool their resources to invest in electrical infrastructure at ports and ships to support cold-ironing, which refers to supplying shore-side power to ships. Such a shore connection can reduce the level of air pollution caused by ships when docking in ports and reduce the operating cost of ships (Ling-Chin and Roskilly, 2016). Therefore, shipping companies should create a sustainability task force to explore areas in which synergies can be created from pooling their resources. Moreover, they should invest in joint research and development on ship or port technologies to implement SSM.

Effective governance mechanisms refer to the underlying contractual governance arrangements which companies undertake with their alliance partners to achieve the inter-firm advantage (Duschek, 2004). Contractual arrangements can range from loose collaboration such as arms-length transaction to tighter types of collaboration such as partnership, joint ventures, alliances, and merger and acquisition. Such an arrangement often delineates the responsibilities of the partnering companies and stipulates the sharing of risks and incentives (Roh et al., 2016). Consequently, contractual arrangements lay the foundation to formalise the exchange of information relating to shipping companies and their partners' sustainability goals, services, and financial data (Zhang and Wang, 2018). Therefore, a tighter arrangement serves as a basis to foster the development of SSM when shipping companies and their partners collaborate to comply with regulations and create mutual sustainability goals and policies through the equitable sharing of risks and rewards.

2.4 Innovation diffusion theory

Innovation diffusion theory explains how new sustainable technologies are accepted and adopted in a company (Yuen et al., 2018a). Green technologies such as new vessel designs, alternative energy resources, radio frequency identification, collaborative planning forecasting and replenishment, and mobile tool-enabled services (Wang et al., 2018; Magsi et al., 2018; Lodro et al., 2018) are crucial to SSM because they improve efficiency, attract more customers, and build a green image for shipping companies. However, for these technologies to be utilised, they have to be accepted by employees who play a key role in the procurement and decision-making of technologies that enhance sustainability (Lin et al., 2019; Sodhro et al., 2017b). Innovation diffusion theory suggests the following five factors that will encourage employees to accept the adoption of new technologies in shipping companies: relative advantage, compatibility, complexity reduction, trialability, and observability.

Relative advantage refers to the extent to which new technology is perceived as better than the technology it substitutes (Yuen et al., 2018a). Essentially, shipping companies or employees will favour technologies that provide clear benefits compared with their existing technologies. These benefits can be measured in economic terms (e.g. higher profitability and lower maintenance cost compared with the current technology), social-prestige factors (e.g. enhancement of image), and satisfaction (e.g. better user experiences). When a shipping company is convinced that a new

technology is noticeably superior to its existing technology, it is more inclined to adopt the new technology. For instance, a scrubber that is able to meet the new IMO 2020 carbon emission regulation is more cost-efficient than other alternatives such as retrofitting engines to consume low carbon fuel or liquified nitrogen gas; hence, it will be favoured by shipping companies. Therefore, shipping companies are interested in evaluating the alternatives and selecting green technologies that confer the most advantage or benefits.

Compatibility refers to the level of integrability of a new technology with the existing technology, business processes, and shipping company systems (Rogers, 2010). A higher level of compatibility increases the expected net benefits of technology because lesser effort by shipping companies is required to integrate the new technology with those already deployed (Vagnani and Volpe, 2017). Continuing with the previous example of the scrubber, only certain ships can be retrofitted with scrubbers that are capable of complying with the IMO 2020 sulphur regulation. Therefore, prior to procuring new technologies, shipping companies should evaluate the scalability and integrability of new technologies with existing technologies, business processes, and systems.

Complexity reduction refers to decreasing the complexity of sustainability technologies when they are considered 'difficult to understand and use' (Rogers, 2010). Technologies that require the development of new skills and understanding will be adopted slower compared with less complex ones. For SSM, shipping companies are less likely to accept a superior technology that is perceived to be complex. Therefore, higher levels of complexity are expected to influence the new sustainable technology adoption negatively in shipping companies because of the required investment of a great amount of resources for understanding and usage of technology (Wang et al., 2018). Consequently, the task of shipping companies is to simplify the use of sustainable technologies or provide training for their users to encourage the adoption of superior technologies.

Trialability refers to the degree to which a new sustainable technology can be tried and tested before adoption (Wang et al., 2018). Trials for the new sustainable technology allow shipping companies to experiment and explore its potentialities and impact on sustainability performance. It also solves problems related to the new technology before fully adopting it. For instance, Rehmatulla et al. (2017) pointed that sea trials of a newly built vessel that is installed with new wind technology are crucial for evaluating the fuel savings of vessel in real operating conditions. Therefore, shipping companies need to implement trials for new sustainable technologies before

their full adoption to allow employees to detect errors and improve familiarity with using the technologies.

Observability refers to the visibility of the processes and results of adopting a new sustainable technology (Vagnani and Volpe, 2017). The processes of using a technology that are highly visible encourage vicarious learning which allows employees to observe and learn from others. This promotes acceptance of the technology. Further, when the benefits of the technology can be easily related by and communicated to employees, it can also encourage acceptance (Hashem and Tann, 2007). Therefore, shipping companies should choose technologies that possess high observability in which the processes and results can be easily learned or related by employees in their management of sustainability.

2.5 Contingency (fit) theory

Contingency (fit) theory proposes the notion that fit affects performance, which, in turn, impels adaptive organisational changes (Donaldson, 2001). The current paper refers 'fit' to the congruency between a shipping company's SSM and contingency variables. Essentially, good fit reflects positive or synergistic effects on organisational performance, whereas poor fit reflects negative or compensatory effects on organisational performance (Yuen et al., 2019b). A review of the SSM literature suggests two typical contingencies, namely, strategic intention and competitive strategies.

Strategic intention is viewed as a contingent variable which affects the implementation of SSM. In a shipping company, the intention of implementing SSM can be altruistic or strategic. It is altruistic, or socially motivated, when a company intends to invest and improve their social and environmental performances without expectation of obtaining any commercial benefits. By contrast, the intention is strategic, or privately motivated, when a shipping company intends to focus on SSM or activities that lead to better economic performance (Yuen and Thai, 2017). The former suggests improving environmental or social performance at the expense of economic performance, whereas the latter aims for the simultaneous improvement of the three performances. From a strategic approach, previous studies have suggested the need for shipping companies to evaluate the performance implications of their sustainability investments before making a decision (Yuen and Thai, 2017). The performance implications can be measured on the basis of return of

investments, market share stakeholder satisfaction (Yuen et al., 2016a), and image and reputation (Yuen et al., 2017b). Therefore, shipping companies should embrace a strategic approach when implementing SSM.

Competitive strategies can be pursued in two ways, namely, cost leadership and differentiation. Consequently, shipping companies can structure their resources or value-chain activities and achieve a competitive advantage in the market by pursuing one of these strategies (Liu and Atuahene-Gima, 2018). A shipping company that pursues cost-leadership emphasises low cost over its competitors such as lower freight. Hence, its SSM activities should be configured, such as improving energy efficiency, centralising facilities, and utilising vessel capacity with the sole purpose of minimising cost (Yuen et al., 2017a). Alternatively, a shipping company can apply differentiation approach by introducing services that are different from its competitors. In this regard, shipping companies can enhance SSM by focusing on its certain aspects that differentiate their services such as sustainability disclosure and cause-related marketing (Lam and Wong, 2018). These aspects of SSM are known to enhance service quality and can attract or retain customers. Therefore, shipping companies need to identify their competitive strategy and implement fitting SSM strategies and activities.

3. Methodology

3.1 Justification of the fuzzy analytic hierarchy process

This study implements the analytic hierarchy process (AHP) to measure the relative importance of the CSFs of SSM. AHP is a practical method that assists in decision-making using a structural hierarchy with different criteria that are weighed by pairwise comparisons (Tseng et al., 2017). AHP methodology has been utilised in various areas because of its ability to assist in complex decision-making problems (Balci et al., 2018a). However, the main drawback of AHP is the application of constant assessment scale that is unable to solve the roughness and uncertainty among different attributes (Kahraman, 2008). The pairwise comparison of AHP includes crisp and exact numbers although individuals' priorities may not be exact in real-life situations. That is, the traditional AHP fails in many cases to reflect the human thinking style (Durán and Aguilo, 2008).

The weakness of AHP related to uncertainty has been improved by utilising fuzzy logic. FAHP is an extension of AHP and a structured technique for organising and analysing complicated

multi-criteria decision-making problems based on mathematics and psychology (Lin and Wang, 2019). FAHP is used instead of the traditional AHP to reflect human logic by improving decision-making where judgements of respondents may not be precise.

In FAHP, fuzzy linguistic variables are converted into fuzzy triangular numbers in order to compare the influential attributes and determine the importance of specific decision variable over another (Khoshand et al., 2019). Hence, FAHP can be applied to provide solutions to uncertain decision-making problems. For example, trade-offs and compromises are needed not only to achieve the different objectives but also to contribute to the joint group decision (Saaty and Vargas, 2012).

Moreover, in the past few years, several methods have been employed and developed for SSM assessment, such as statistical analysis (Yuen et al., 2017, 2018), structural equation modelling (Shin et al., 2017), multi-criteria decision method (Ren and Liang, 2017), and mixed integer programming (Ahmed and Sarkar, 2018). Among them, the FAHP is most broadly used to assess the importance of decision criteria in various industries, including shipping and port. For example, by using the FAHP approach, Chiu et al. (2014) formulated a FAHP model including 5 dimensions and 13 factors to evaluate the port's green operation performance. Park et al. (2018) explored FAHP application to analyse priority factors during the acquisition of second-hand ships from the perspectives of shipping companies; meanwhile, Kim and Seo (2019) used an empirical FAHP to evaluate the response direction of Korean shipping companies to SOX regulations.

Additionally, comparing the aforementioned methods, FAHP is most suitable because it employs pairwise comparisons and allows decision-makers to have a better understanding of the relative importance of interacting criteria (Calabrese et al., 2019). Besides, it also allows formulating decision-making criteria in multiple hierarchical levels. Thus, FAHP has been chosen as the most applicable technique for the analysis of SSM in shipping companies.

3.2 Process of methodology

Fig. 1 presents a two-stage process of methodology.

<Insert Figure 1 Here>

Initially, the process was conducted to identify the criteria and sub-criteria of SSM based on the five main theories by reviewing the literature and interviewing academic and industry experts specialising in sustainable shipping development in Vietnam. Based on these criteria and sub-criteria, surveys were designed and administered to collect the data. The next step was completed by applying the FAHP method to calculate the weights of criteria and sub-criteria using a linguistic scale. Finally, the ranking and assessment of the criteria and sub-criteria were analysed after checking the comparison consistency.

3.3 The AHP model

The elemental steps in applying AHP are as follows:

3.3.1 Step 1: Setting up the hierarchical model

Drawing on the review of the literature and interviews with five shipping industry experts, we designed a three-level hierarchical model. The interviewees have at least 15 years of experience in sustainability management in the shipping industry. As indicated in Fig. 2, the AHP model includes five main CSFs mentioned in the previous section (i.e. stakeholders' focus, intra-firm management, inter-firm collaboration, new technology acceptance, and strategic fit). Additionally, Fig. 2 also presents the developed 20 sub-criteria of CSFs.

<Insert Figure 2 Here>

The descriptions of the sub-criteria and the supporting references which clarify their influence on SSM are illustrated in the Appendix. The criterion ‘stakeholders' focus’ includes five sub-criteria: shareholders' focus, vendors' focus, shippers' focus, employees' focus, and society's focus. The ‘intra-firm management’ criterion consists of four sub-criteria: physical facilities, financial resource, sustainable knowledge, and organisational culture. The ‘inter-firm collaboration’ criterion comprises four sub-criteria: inter-firm relationship management, inter-firm knowledge sharing, complementary resources and capabilities, and effective governance mechanisms. In addition, the ‘new technology acceptance’ criterion includes five sub-criteria: relative advantage, compatibility, complexity reduction, trialability, and observability. Lastly, the ‘strategic fit’ criterion encompasses two sub-criteria: fit with strategic intention and fit with competitive strategies.

3.3.2 Step 2: Generating the pairwise comparison matrices

A survey questionnaire with a 9-point ranking scale is designed to indicate the relative importance of paired evaluation criteria. The responses of interviewees on the paired comparison of the criteria formed the pairwise comparison matrices.

3.3.3 Step 3: Determining the relative weights of the decision criteria.

A reciprocal value is calculated by the inverse comparison:

$$a_{ij} = \frac{1}{a_{ji}}, \quad (1)$$

where a_{ij} represents the importance of the *i*th (*j*th)element.

3.4 The FAHP model

In this section, the outcomes of the AHP approach are combined with the fuzzy set theory to generate the FAHP results. The procedure of the FAHP consists of the following six steps.

3.4.1 Step 1: Constructing a pairwise comparison matrix

The following matrix $\tilde{A}$ presents an $n \times n$ pairwise comparison matrix for linguistics variables with their respectively fuzzy scales:

$$\widetilde{A} = \begin{bmatrix} 1 & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \tilde{a}_{21} & 1 & \cdots & \tilde{a}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & 1 \end{bmatrix} \quad (2)$$

$$\tilde{a}_{12} = \begin{cases} (1/p_i, 1/n_i, 1/m_i); & for \ \forall i < j, \\ (1,\ 1,\ 1); & for \ \forall i = j \\ (m_i,\ n_i,\ p_i\ ); & for \ \forall i > j \end{cases} \quad (3)$$

The normalised fuzzy decision matrix is indicated as follows:

$$\tilde{A} = [\tilde{a}_{ij}] \quad (4)$$

i, *j* = 1, 2, ... n

3.4.2 Step 2: Calculating the fuzzy numbers

Zadeh (1965) proposed the concept of a fuzzy set as a class of objects with a continuum of grades of membership ranging between zero and one. If the value is equal to one, the element completely lies in the set; if the value is zero, the element does not lie in the set (Büyüközkan and Çifçi, 2012). A triangular fuzzy number (TFN) is composed of the following three points. A TFN is simplified as (*l*, *m* ,*u*), where the parameters *l*, *m*, and *u* denote the smallest possible value, the most promising value, and the largest possible value that provide a fuzzy set, respectively (Rahimi Ghazikalayeh et al., 2013). A triangular membership function is summarised as follows:

$$\mu_M\ (x)\begin{cases} \frac{x-l}{m-l},\ l <\ \ x < m \\ 1, \qquad\qquad x = m \\ \frac{u-x}{x-m}\quad , m < x < u \\ \qquad 0, l \geq x \geq u \end{cases} \tag{5}$$

Table 1 indicates the TFN numbers used to remove decision-making uncertainties in this study, whereas Fig. 3 presents fuzzy membership function for the linguistic expressions for key CSFs and sub-criteria.

<Insert Table 1 here>

<Insert Figure 3 Here>

If $\tilde{A}_1 =\ (l_1,\ m_1\ , u_1\ )$ and $\tilde{A}_2 =\ (l_2,\ m_2, u_2\ )$ represent two TFNs, then the algebraic operations can be expressed as follows:

$$\tilde{A}_1 +\ \tilde{A}_2 =\ (l_1, m_1\ , u_1\ ) +\ (l_2, m_2, u_2\ ) = (\ l_1 + l_2, m_1\ + m_2\ , u_1\ +\ u_2\ ) \tag{6}$$

$$\tilde{A}_1 -\ \tilde{A}_2 =\ (l_1, m_1\ , u_1\ ) -\ (l_2, m_2, u_2\ ) = (\ l_1 - l_2, m_1\ - m_2\ , u_1\ -\ u_2\ ) \tag{7}$$

$$\tilde{A}_1 \times\ \tilde{A}_2 =\ (l_1, m_1\ , u_1\ ) \times\ (l_2, m_2, u_2\ ) = (\ l_1 \times l_2, m_1\ \times m_2\ , u_1\ \times\ u_2\ ) \tag{8}$$

$$\tilde{A}_1 \div\ \tilde{A}_2 =\ (l_1, m_1\ , u_1\ ) \div\ (l_2, m_2, u_2\ ) = (\ l_1/l_2, m_1\ /m_2\ , u_1\ /u_2\ ) \tag{9}$$

$$\alpha \times\ \tilde{A}_1 =\ (\propto l_1, \propto m_1\ , \propto u_1\ )\ where\ \ \propto > 0 \tag{10}$$

$$\tilde{A}_1^{-1} =\ (l_1, m_1\ , u_1\ )^{-1} = \left(\frac{1}{l_1}\ , \frac{1}{m_1}\ , \frac{1}{u_1}\ \right). \tag{11}$$

3.4.3 Step 3: Calculating the fuzzy weights

The fuzzy weight of each criterion in the fuzzy decision matrix are identified using the geometric mean technique, where the fuzzy geometric mean of a fuzzy comparison value of criterion *i* to each criterion is formulated as follows:

$$Z_i = \ (a_{i1} \ x \ a_{i2} \ \ x \ldots \ a_{in} \ )^{1/n} \ \ \forall i = 1,2, \ldots, n. \tag{12}$$

The fuzzy weight of the *i*thith criterion, considered a TFN, is calculated as follows:

$$W_i = Z_i \ x \ \ (Z_1 \ x \ Z_2 \ \ x \ldots \ Z_n \ )^{-1} \ \ \forall i = 1,2, \ldots, n. \tag{13}$$

3.4.4 Step 4: Calculating the consistency ratio

An inconsistency may occur in the comparisons of the criteria; hence, the consistency ratio (CR) for each matrix should be ensured. If CR is unacceptable, the paired comparison should be reconsidered. The CR is calculated by

$$CR = \frac{CI}{RI} \tag{14}$$

$$CI = \frac{\lambda_{max} - \ n}{n \ - \ 1}, \tag{15}$$

where *n* is the size of the pairwise comparison matrix, λ_{max} is the maximum value of the matrix, CI is the consistency index, and RI is the random index (Table 2).

<Insert Table 2 here>

Saaty (1988) suggests that the consistency of the matrix is acceptable if $\mathrm{CR} \leq 0.10$. Otherwise, decision-makers need to revise the original value in the pairwise comparison matrix.

3.4.5 Step 5: Defuzzification

The criteria weights need to be transformed into non-fuzzy values through defuzzification because they are still in the form of fuzzy triangular values. Following the suggestion of the previous studies (e.g. Yeh and Xing, 2016; Park et al., 2018), for defuzzification, we apply the best non-fuzzy performance (BNP) value based on the centre of the area or centroid. The BNP value of a fuzzy number is derived as follows:

$$BNP_i \ \ value = \ \frac{[(u_i - l_i) + (m_i - l_i)]}{3} + \ \ l_i \ \ \forall i = 1,2, \ldots \ \ n \quad (16)$$

The BNP values can be used to rank the criteria. Those criteria obtaining a larger number of BNP values are considered as having a larger effect than other criteria.

3.4.6 Step 6: Normalisation

For the purpose of comparing each criterion and sub-criterion and determining their relative importance, these above BNP values need to be normalised:

$$NW_i = \ \frac{BNP_i}{\sum_{i=1}^{n} BNP_i} \forall i = 1,2, \ldots \ \ n \quad (17)$$

3.4 Data collection

The data were collected in order to apply the FAHP analysis for ranking relative importance of CSFs of SSM. For this purpose, a survey questionnaire consisting of pairwise comparisons was designed to collect the relevant responses from managers or leaders of shipping companies in Vietnam. Vietnam is considered a booming economy, particularly considering its shipping industry. Vietnam has the 30th largest vessel ownership in the world, with a total of 991 commercial vessels comprising around 9.2 million DWT capacity (UNCTAD, 2018). It also has one of the highest maritime connectivity in Asia (UNCTAD, 2018). However, research on SSM in Vietnam is inadequate despite the increasing attention and concern of the government and shipping companies over the implementation of sustainable standards such as IMO's International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), Global Maritime Energy Efficiency Partnership (GloMEEP), and International Convention for the Prevention of Pollution from Ships (MARPOL).

The survey questionnaire was designed by considering the suggestion of two academic experts and three industry experts, who had at least 15 years of working experience and participated in major research and projects on sustainable shipping development in Vietnam. They have examined and approved the readability and applicability of the contents. After revising the survey questionnaire, the final version of the survey consisted of 42 pairwise comparisons and 4 profiling questions. The survey was administered electronically from October to December in 2018.

The targeted respondent group includes shipping companies that have implemented SSM in Vietnam. The sampling frame was built from the online database of the Ministry of Transportation and Vietnam National Shipping Lines, whereby a combined population size of 981 companies are obtained. A total of 777 companies were excluded because they did not report any involvements in SSM in the online database. Toward to the end of December 2018, as a result, the survey was sent to a total of 224 companies via e-mail, and 40 responses were returned. The response rate was approximately 17.86%. However, four of the responses were incomplete; hence, only 36 valid responses were used for further analysis.

4. Results

4.1. Profile of respondents

The demographic characteristics of the 36 survey respondents are illustrated in Table 3. The respondents are capable of evaluating the CSFs of SSM as all of them are holding managerial positions. The majority of the respondents are branch or division managers. It is worth noting that over 65% of the respondents are working in relatively smaller firms (i.e. the number of employees is below 100). In addition, 61.11% of the respondents are from container shipping companies, whereas 38.89% are from the dry and liquid bulk shipping companies.

<Insert Table 3 here>

4.2. Results of the FAHP

The results illustrate that the CR of each main criterion was within the standard acceptable value (0.1). Therefore, the data meet the consistency requirements.

After ensuring that the responses are consistent, we calculated the weights of the selected key criteria and sub-criteria. The local and global weights of each key criterion and sub-criterion are determined using FAHP and are shown in Table 4. Results reveal that the most important main criterion for enabling SSM is stakeholders' focus with a relative weight of 0.298. It is followed by the following: intra-firm management (0.248), new technology acceptance (0.156) and inter-firm collaboration (0.154). The least important main criterion is strategic-fit, which has a weight of 0.143.

We calculated the local weights of each main criterion for sub-criteria as well. The results of the ‘stakeholders' focus’ criterion suggest that shareholders' focus (0.300) is the most important criterion, followed by vendors' focus (0.243), society's focus (0.175), shippers' focus (0.147), and employees' focus (0.134). Considering ‘intra-firm management’ criterion, we determine that the first sub-criterion is financial resource (0.376), which is followed by physical assets (0.317), sustainable knowledge (0.189), and organisational culture (0.118).

Regarding the ‘inter-firm collaboration’ criterion, the most important sub-criterion is inter-firm knowledge sharing (0.344), followed by inter-firm relationship management (0.326), complementary resources and capabilities (0.211), and effective governance mechanisms (0.120). The results for the ‘new technology acceptance’ criterion point out that the most important sub-criterion is relative advantage (0.296). This is then followed by complexity reduction (0.199), compatibility (0.180), observability (0.173), and trialability (0.152). For the ‘strategic fit’ criterion, fit with competitive strategies (0.519) is the most important sub-criterion, followed by fit with strategic intention (0.481).

Finally, we calculated the global weights of the sub-criteria which are obtained by multiplying the local weight of each sub-criterion with the local weight of the corresponding key criteria. The results show that the five most important sub-criteria for SSM are ‘financial resource’ (0.093), ‘shareholders' focus’ (0.089), ‘physical assets’ (0.079), ‘competitive strategies’ (0.074), and ‘vendors' focus’ (0.072). After the top five sub-criteria, the next five sub-criteria in descending order are as follows: ‘strategic intention’ (0.069), ‘inter-firm knowledge sharing’ (0.057), ‘society's focus’ (0.052), ‘inter-firm relationship management’ (0.050), and ‘sustainable knowledge’ (0.047). Next are those from the 11th to 15th ranking: ‘relative advantage’ (0.046), ‘shippers' focus’ (0.044), ‘employees' focus’ (0.040), ‘complementary resources and capabilities’ (0.032), and ‘complexity reduction’ (0.031). Lastly, the five least important sub-criteria are ‘effective governance mechanisms’ (0.018), ‘trialability’ (0.024), ‘observability’ (0.027), ‘compatibility’ (0.028), and ‘organisational culture’ (0.029).

<Insert Table 4 here>

5. Discussion

‘Stakeholders' focus’ is perceived to be the most important CSF of SSM. This finding resonates with stakeholder theory which explains the basis for engaging SSM. The theory argues that a shipping company cannot maximise its economic performance without addressing the social and environmental needs of its stakeholders, including shareholders, suppliers, customers, employees, and the community. These stakeholders can exert pressure on shipping companies to practise sustainability by withholding valuable resources if their needs are not met. Hence, shipping companies are required to focus on their stakeholders' needs when managing sustainability.

Among the sub-criteria, ‘shareholders' focus’ is found to be the most important. A possible explanation is that shareholders have the largest stake in the shipping company because they own the business. Hence, focusing on addressing their sustainability requirements can garner stronger commitment from the shareholders and attract greater investments. The second important sub-criterion is ‘vendors' focus’ because of the fact that the shipping companies have to work with a large number of suppliers such as terminal operators and feeder companies, who play an important role in supporting the shipping companies' services. Hence, focusing on addressing their needs such as assuring fair transactions can improve their relationships with vendors and allow shipping companies to enjoy discounts from engaging their services. ‘Society's focus’ is ranked as the third most important sub-criterion. Addressing society's needs can help shipping companies garner local support and improve their image and reputation. Consequently, shipping companies can enjoy opportunities for transporting national goods or subsidies. ‘Shippers' focus’ and ‘employees’ focus’ are ranked fourth and fifth, respectively. Focusing on addressing shippers' needs is necessary given that they are increasingly using shipping companies' involvement in sustainability as a basis to award shipping tenders. Similarity, focusing on employees' needs in sustainability management can improve their satisfaction and loyalty at work, which can drive their productivity.

The second most important CSF is ‘intra-firm management’. This result reflects the main content of RBV theory which refers to deploying, bundling, and exploiting the internal resources of a shipping company to manage sustainability. The most important sub-criterion is ‘financial resource’, which is necessary to support all operational activities to enhance economic performance (e.g. investing in larger ships), social performance (e.g. improving living and working conditions of seafarers), and environmental performance (e.g. using renewable energy resources

for ships). Therefore, having strong and stable financial resources can contribute to shipping companies' ability to pursue or implement social or environmental programmes that complement their business strategies. ‘Physical assets’ ranks second. The installation or deployment of eco-friendly assets such as green ships can provide financial benefits (e.g. reducing operating costs of ships) and non-financial benefits (e.g. enhancing safety and corporate image). Hence, shipping companies should allocate financial resources for SSM and set budgets for investments in eco-friendly assets to manage sustainability. The third and the fourth rankings belong to ‘sustainable knowledge’ and ‘organisational culture’, respectively. Concerning ‘sustainable knowledge’, possessing good knowledge on managing sustainability would indicate that employees are more capable of exploiting the current processes, for instance, through implementing continuous improvement programmes and exploring innovative solutions, such as, through investing in research and development on new technologies and inventing revolutionary management practices. Lastly, regarding ‘organisational culture’, shipping companies should create an environment whereby employees are supportive of and committed to sustainability. This can be achieved by espousing sustainability values in the vision, mission, goals, and objectives of the shipping company or via communication from the management.

‘New technology acceptance’ is the CSF that is ranked third. The surveyed shipping companies view encouraging employees to accept the adoption of new technologies as a CSF of SSM. In particular, the results suggest that shipping companies view technologies that offer the most advantage, hence ‘relative advantage’, as the most important sub-criterion under this theme. When a shipping company is convinced that new technology is noticeably superior to its existing technology, it is more inclined to adopt the new technology. Hence, shipping companies should evaluate the alternatives and select new technologies that confer the optimum economic, social and environmental benefit to manage sustainability in an attempt to garner acceptance from employees.

‘Complexity reduction’ and ‘compatibility’ are ranked second and third. The decrease in the complexity of technologies can reduce the investment of financial and human resources for the implementation of new technologies. Consequently, this reduces shipping companies' cost of using the technologies to manage sustainability and, hence, acceptance. Additionally, a high level of compatibility between new technology and a shipping company's current technology and business

processes can translate to fewer problems when integrating with or replacing existing technologies. This encourages the adoption of new technologies. The last criterion is ‘trialability’. Technologies with high trialability allow shipping companies to detect errors and improve their familiarity with technology before fully adopting them. Further, such technologies encourage vicarious learning and promote the acceptance of new technologies.

‘Inter-firm collaboration’ is the fourth CSF of SSM. This CSF corroborates the relational-view theory, which improves SSM through the creation of inter-firm relationships and resources. Two sub-criteria that are relatively high ranking are ‘inter-firm knowledge sharing’ (ranked first) and ‘inter-firm relationship management’ (ranked second). Information sharing between shipping companies and their partners is crucial because it improves decision-making concerning the management of sustainability and can lead to time and money saving or service quality improvements. Therefore, sharing of sustainability information can be facilitated by organising inter-firm conferences and workshops. Regarding ‘inter-firm relationship management’, a tighter relationship between shipping companies and their partners can create complex inter-firm ties and build partners' trust in shipping companies' sustainability commitment. The next in rank is ‘complementary resources and capabilities’ (ranked third), and ‘effective governance mechanisms’ (ranked fourth). The pooling and sharing of resources can help shipping companies create distinctive inter-firm resources to manage sustainability, whereas contractual governance arrangements can foster the development of SSM through inter-firm collaboration to comply with sustainability regulations and attain sustainability goals and objectives collectively.

‘Strategic fit’ is ranked last in terms of enhancing SSM. This CSF concerns the fit between SSM and shipping companies' strategies or environment. The finding shows that shipping companies view SSM to fit with their ‘competitive strategies’ as more important than with their ‘intention’. The former concerns ensuring that SSM activities are aligned with the chosen strategy of a shipping company which could be either cost- or differentiation-oriented, whereas the latter focuses on ensuring that SSM activities yield economic benefits for a shipping company.

Considering the global weights, we determine that two of the top five sub-criteria belong to the CSF on ‘intra-firm management’ (with ‘financial resource’ ranked first whereas ‘physical assets’ ranked third overall). These findings highlight a high level of practicality and inward-orientation amongst shipping companies in their assessments of the CSFs of SSM. A possible

explanation is that most of the surveyed shipping companies are medium- or small-scaled companies that have limited slack resources. Hence, these shipping companies' concern is primarily related to monetary resources, tangible infrastructures, and equipment to improve SSM.

For the remaining three sub-criteria, ‘shareholders' focus’ and ‘vendors' focus’ which are the components of ‘stakeholders' focus’ are ranked second and fifth, respectively. This highlights the importance of satisfying the needs of stakeholders, in particular, shareholders and vendors (i.e. terminal operators and feeder companies) when managing SSM to ensure that the operations of the shipping company are legitimised and supported by a group of satisfied and committed stakeholders (Schaltegger et al., 2017). The last sub-criterion that is ranked among the top five is ‘fit with competitive strategies’ (ranked fourth overall). This further supports the business case of SSM, whereby its implementation should not be considered in isolation but aligned with the strategy of the shipping company.

6. Conclusions

6.1 Summary of findings

The current research employs five main management theories to identify the key CSFs of SSM. Based on the interpretation of the theories, this study proposed 5 CSFs and 20 sub-criteria that can improve SSM. A survey questionnaire was designed and administered on 36 shipping companies in Vietnam. Thereafter, the FAHP methodology is applied to analyse the obtained survey data. The following are the key findings of this study:

- The CSFs of SSM are stakeholders' focus, intra-firm management, inter-firm collaboration, new technology acceptance, and strategic fit.
- In descending order of their importance, the CSFs are (1) stakeholders' focus, (2) intra-firm management, (3) new technology acceptance, (4) inter-firm collaboration, and (5) strategic fit.
- Stakeholders' focus is the most important factor influencing the success of SSM. It highlights the important role of stakeholder theory which explains that the basis of engaging SSM includes addressing the economic, social, and environmental needs of shipping companies' stakeholders.

- In terms of global rankings, the five most important sub-criteria influencing the success of SSM are ‘financial resource’, ‘shareholders' focus’, ‘physical assets’, ‘vendors' focus’, and ‘fit with competitive strategies’.
- It can be concluded that the most important sub-criteria are primarily related to monetary resources, tangible infrastructures, and equipment to improve the success of SSM. Additionally, SSM implementation in shipping companies can be improved by addressing the needs of stakeholders and aligning SSM activities with shipping companies' strategies.

6.2 Theoretical and managerial implications

This research contributes to theory in several ways. Firstly, it provides a holistic view of the CSFs which underpin SSM. There is currently a lack of theoretical framework that explains the factors that improve SSM. This research introduces five management theories: (1) stakeholder theory, (2) RBV theory, (3) relational-view theory, (4) innovation diffusion theory, and (5) contingency theory. These theories identify and can explain the CSFs of SSM from different perspectives. For instance, the stakeholder theory proposed that SSM can be improved by focusing on stakeholders' needs. RBV theory focuses on configuring the internal resources of a shipping company to manage sustainability. The relational-view theory focuses on establishing relationships with partners and building inter-firm resources. Innovation diffusion theory focuses on enhancing the acceptance of technologies, which is crucial for SSM. Lastly, contingency theory concerns aligning SSM with the environment and strategy of a shipping company.

Secondly, this research also enriches the literature by comparing and examining the importance of each theory in relation to improving the effectiveness or efficiency of SSM. Most existing research has analysed each theory in isolation. The results imply that stakeholder theory is the most influential factor that improves SSM. This is followed by the RBV theory, innovation diffusion theory, relational-view theory, and contingency theory. The global rankings of the sub-criteria seem to imply that an inward orientation has greater importance on improving SSM compared with those that concern outward-orientation.

The findings of this research also implicate policy formulation, in particular, on the improvement of SSM. First, it contextualises and operationalises the theories into meaningful criteria and sub-criteria for shipping companies to improve sustainability management. Consequently, it addresses the question of how SSM should be implemented to maximise a shipping company sustainability performance. Second, it facilitates resource allocation in a shipping company to improve its SSM. Resources of a shipping company are limited; hence, the company needs to allocate resources to those factors that have a larger impact on SSM. The results reveal that shipping companies should allocate more resources on managing their stakeholders, followed by focusing on developing internal resources such as dedicating adequate financial resources for SSM and investing in eco-friendly assets such as green ships and equipment. Next, resources should also be dedicated to improving employees' acceptance of technology, which can be achieved, for instance, by emphasising the advantages that the new technologies can confer or ensuring that the technologies are compatible with the current technologies, systems, and processes of the shipping company. Thereafter, resources should also be allocated to facilitate inter-firm collaboration to manage sustainability, such as developing contractual agreements to collaborate and solve sustainability issues or managing relationships by fostering trust. Finally, shipping companies should ensure that their sustainability strategy is consistent with their overall competitive strategy. Essentially, a shipping company that is pursuing cost leadership should focus on aspects of SSM that reduce operational cost, whereas a shipping company pursuing differentiation should focus on aspects of SSM that improve its image and service quality.

6.3 Limitations and recommendations

There are a few limitations in this research. Firstly, the data are collected based on the perception of shipping companies, which may suffer from CR. Even though the CR has been tested and found to be acceptable in this research, it may invariably affect the accuracy of the results. Therefore, the current study recommends combining FAHP with other qualitative methodologies such as the Delphi method to complement pairwise comparisons in future research.

Secondly, the findings and conclusions drawn from this research might only be limited to Vietnam's shipping sector, which mainly includes medium and small-scale shipping companies which handles local and regional shipments. Consequently, the results may not be applicable to large shipping companies. Therefore, these results can be cross-validated with large shipping

companies or other countries' shipping sector to examine their generalisability. Sub-group analysis based on the firm size, sector, and scope of operations can also be conducted in the future.

Thirdly, the majority of the respondents are branch or division managers in shipping companies who are responsible for SSM decision. However, in some criteria or sub-criteria, such as employee's focus, sustainable knowledge, and new technology acceptance, the role of employees should be involved to clarify how SSM is implemented in practice. Therefore, in the future, it will be meaningful to explore how the staff of different work levels makes different judgments in the implementation of SSM.

Finally, while the findings of the research allude to the importance of the CSFs in influencing SSM, the effects of the CSFs and SSM on the business performance of shipping companies are not examined in this research. Future research can consider examining these effects. This will draw greater implications for managers to maximise their business performance by focusing on the factors that yield greater impact on business performance.

REFERENCES

1. Al-Debei, M.M., Avison, D., 2010. Developing a unified framework of the business model concept. *European Journal of Information Systems* 19(3), 359-376.
2. Ahmed, W., Sarkar, B., 2018. Impact of carbon emissions in a sustainable supply chain management for a second generation biofuel. *Journal of Cleaner Production* 186, 807-820.
3. Balci, G., Cetin, I. B., & Esmer, S. 2018a. An evaluation of competition and selection criteria between dry bulk terminals in Izmir. *Journal of Transport Geography*, 69, 294-304.
4. Balci, G., Cetin, I.B., Tanyeri, M., 2018b. Differentiation of container shipping services in Turkey. *Transport Policy* 61, 26-35.
5. Balland, O., Girard, C., Erikstad, S.O., Fagerholt, K., 2015. Optimized selection of vessel air emission controls—moving beyond cost-efficiency. *Maritime Policy & Management* 42(4), 362-376.
6. Bocken, N., Short, S., Rana, P., Evans, S., 2013. A value mapping tool for sustainable business modelling. *Corporate Governance* 13(5), 482-497.
7. Busby, J.S., 2019. The co-evolution of competition and parasitism in the resource-based view: A risk model of product counterfeiting. *European Journal of Operational Research*.
8. Büyüközkan, G., Çifçi, G., 2012. A combined fuzzy AHP and fuzzy TOPSIS based strategic analysis of electronic service quality in healthcare industry. *Expert Systems with Applications* 39(3), 2341-2354.
9. Calabrese, A., Costa, R., Levialdi, N., Menichini, T., 2019. Integrating sustainability into strategic decision-making: A fuzzy AHP method for the selection of relevant sustainability issues. *Technological Forecasting and Social Change* 139, 155-168.

10. Carter, C.R., Jennings, M.M., 2002. Social responsibility and supply chain relationships. *Transportation Research Part E: Logistics and Transportation Review* 38(1), 37-52.
11. Chandio, A.A., Zhu, D. and Sodhro, A.H., 2014. Integration of inter-connectivity of information system (i3) using web services. *arXiv preprint arXiv:1405.3724.*
12. Cheng, T., Zanjirani Farahani, R., Lai, K.-h., Sarkis, J., 2015. Sustainability in maritime supply chains: Challenges and opportunities for theory and practice. *Transportation Research Part E: Logistics and Transportation Review* 78, 1-2.
13. Child, J., Faulkner, D., Tallman, S., Hsieh, L., 2019. *Cooperative Strategy: Managing Alliances and Networks*. Oxford University Press.
14. Chin, T.A., Tat, H.H., Sulaiman, Z., 2015. Green supply chain management, environmental collaboration and sustainability performance. *Procedia Cirp* 26, 695-699.
15. Chiu, R.-H., Lin, L.-H., Ting, S.-C., 2014. Evaluation of green port factors and performance: a fuzzy AHP analysis. *Mathematical Problems in Engineering* 2014.
16. Cross, R., Parker, A., Prusak, L., Borgatti, S.P., 2001. Knowing what we know: supporting knowledge creation and sharing in social networks. *Organizational Dynamics* 30(2), 100-120.
17. Cullinane, K., Cullinane, S., 2019. *Policy on Reducing Shipping Emissions: Implications for "Green Ports",* Green Ports. Elsevier, pp. 35-62.
18. Donaldson, L., 2001. *The Contingency Theory of Organizations*. Sage Publications Limited.
19. Durán, O., Aguilo, J., 2008. Computer-aided machine-tool selection based on a Fuzzy-AHP approach. *Expert Systems with Applications* 34(3), 1787-1794.
20. Durst, S., Runar Edvardsson, I., 2012. Knowledge management in SMEs: a literature review. *Journal of Knowledge Management* 16(6), 879-903.
21. Duschek, S., 2004. Inter-firm resources and sustained competitive advantage. *Management Revue*, 53-73.
22. Dyer, J.H., Singh, H., Hesterly, W.S., 2018. The relational view revisited: A dynamic perspective on value creation and value capture. *Strategic Management Journal* 39(12), 3140-3162.
23. Ellram, L.M., Murfield, M.L.U., 2017. Environmental Sustainability in Freight Transportation: A Systematic Literature Review and Agenda for Future Research. *Transportation Journal*, 56(3), 263-298.
24. Freeman, R.E., 2010. *Strategic Management: A Stakeholder Approach*. Cambridge University Press.
25. Freudenreich, B., Lüdeke-Freund, F., Schaltegger, S., 2019. A stakeholder theory perspective on business models: Value creation for sustainability. *Journal of Business Ethics*, 1-16.
26. Giannakopoulou, E.N., Thalassinos, E.I., Stamatopoulos, T.V., 2016. Corporate governance in shipping: An overview. *Maritime Policy & Management* 43(1), 19-38.
27. Govindan, K., Khodaverdi, R., Jafarian, A., 2013. A fuzzy multi criteria approach for measuring sustainability performance of a supplier based on triple bottom line approach. *Journal of Cleaner Production* 47, 345-354.
28. Hashem, G., Tann, J., 2007. The adoption of ISO 9000 standards within the Egyptian context: a diffusion of innovation approach. *Total Quality Management* 18(6), 631-652.
29. Herremans, I.M., Nazari, J.A., Mahmoudian, F., 2016. Stakeholder relationships, engagement, and sustainability reporting. *Journal of Business Ethics* 138(3), 417-435.

30. Jensen, J.A., Cobbs, J.B., Turner, B.A., 2016. Evaluating sponsorship through the lens of the resource-based view: The potential for sustained competitive advantage. *Business Horizons* 59(2), 163-173.
31. Joyce, A., Paquin, R.L., 2016. The triple layered business model canvas: A tool to design more sustainable business models. *Journal of Cleaner Production* 135, 1474-1486.
32. Kahraman, C., 2008. *Fuzzy Multi-criteria Decision Making: Theory and Applications with Recent Developments*. Springer Science & Business Media.
33. Khoshand, A., Rahimi, K., Ehteshami, M., Gharaei, S., 2019. Fuzzy AHP approach for prioritizing electronic waste management options: A case study of Tehran, Iran. *Environmental Science and Pollution Research*, 1-12.
34. Kim, A.-R., Seo, Y.-J., 2019. The reduction of SOx emissions in the shipping industry: The case of Korean companies. *Marine Policy* 100, 98-106.
35. Lai, K.-H., Wong, C.W., Lun, Y.V., Cheng, T., 2013. Shipping design for compliance and the performance contingencies for shipping firms. *Transportation Research Part E: Logistics and Transportation Review* 55, 74-83.
36. Lam, J.S.L., Lim, J.M., 2016. Incorporating corporate social responsibility in strategic planning: Case of ship-operating companies. *International Journal of Shipping and Transport Logistics* 8(3), 273-293.
37. Lam, J.S.L., Wong, H.N., 2018. Analysing business models of liner shipping companies. *International Journal of Shipping and Transport Logistics* 10(2), 237-256.
38. Lee, T., Nam, H., 2017. A study on green shipping in major countries: In the view of shipyards, shipping companies, ports, and policies. *The Asian Journal of Shipping and Logistics* 33(4), 253-262.
39. Lin, Q., Wang, D., 2019. Facility layout planning with SHELL and Fuzzy AHP method based on human reliability for operating theatre. *Journal of Healthcare Engineering* 2019.
40. Lin, Y., Jin, X., Chen, J., Sodhro, A. H., & Pan, Z., 2019. An analytic computation-driven algorithm for Decentralized Multicore Systems. *Future Generation Computer Systems*, *96*, 101-110.
41. Ling-Chin, J., Roskilly, A., 2016. Investigating a conventional and retrofit power plant on-board a Roll-on/Roll-off cargo ship from a sustainability perspective–A life cycle assessment case study. *Energy Conversion and Management* 117, 305-318.
42. Lirn, T.-C., Lin, H.-W., Shang, K.-C., 2014. Green shipping management capability and firm performance in the container shipping industry. *Maritime Policy & Management* 41(2), 159-175.
43. Liu, W., Atuahene-Gima, K., 2018. Enhancing product innovation performance in a dysfunctional competitive environment: The roles of competitive strategies and market-based assets. *Industrial Marketing Management* 73, 7-20.
44. Lodro, M.M., Majeed, N., Khuwaja, A.A., Sodhro, A.H. and Greedy, S., 2018, March. Statistical channel modelling of 5G mm Wave MIMO wireless communication. In *2018 International Conference on Computing, Mathematics and Engineering Technologies (iCoMET)*, 1-5. IEEE.
45. Lun, Y.V., Lai, K.-h., Wong, C.W., Cheng, T., 2016. *Green Shipping Management*. Springer, pp. 17-29.
46. Magsi, H., Sodhro, A. H., Chachar, F. A., Abro, S. A. K., Sodhro, G. H., & Pirbhulal, S. 2018, March. Evolution of 5G in Internet of medical things. In *2018 International*

Conference on Computing, Mathematics and Engineering Technologies (iCoMET), 1-7. IEEE.
47. Muzammal, M., Talat, R., Sodhro, A. H., & Pirbhulal, S., 2020. A multi-sensor data fusion enabled ensemble approach for medical data from body sensor networks. *Information Fusion*, *53*, 155-164.
48. Nurani, A.I., Pramudyaningrum, A.T., Fadhila, S.R., Sangadji, S., Hartono, W., 2017. Analytical Hierarchy Process (AHP), Fuzzy AHP, and TOPSIS for determining bridge maintenance priority scale in Banjarsari, Surakarta, *International Journal of Science and Applied Science: Conference Series*, pp. 60-71.
49. Octaviannand, R., Pandjaitan, N.K., Kuswanto, S., 2017. Effect of job satisfaction and motivation towards employee's performance in XYZ shipping company. *Journal of Education and Practice* 8(8), 72-79.
50. Pagell, M., Shevchenko, A., 2014. Why research in sustainable supply chain management should have no future. *Journal of Supply Chain Management* 50(1), 44-55.
51. Pang, K., Lu, C.-S., 2018. Organizational motivation, employee job satisfaction and organizational performance: An empirical study of container shipping companies in Taiwan. *Maritime Business Review* 3(1), 36-52.
52. Park, K.-S., Seo, Y.-J., Kim, A., Ha, M.-H., 2018. Ship acquisition of shipping companies by sale & purchase activities for sustainable growth: Exploratory Fuzzy-AHP application. *Sustainability* 10(6), 1763.
53. Parviainen, T., Lehikoinen, A., Kuikka, S., Haapasaari, P., 2018. How can stakeholders promote environmental and social responsibility in the shipping industry? *WMU Journal of Maritime Affairs* 17(1), 49-70.
54. Progoulaki, M., Roe, M., 2011. Dealing with multicultural human resources in a socially responsible manner: a focus on the maritime industry. *WMU Journal of Maritime Affairs* 10(1), 7-23.
55. Rahimi Ghazikalayeh, A., Amirafshari, M., Mkrchyan, H., Taji, M., 2013. Application of fuzzy hybrid analytic network process in equipment selection of open-pit metal mines. *International Journal of Research in Industrial Engineering* 2(3), 35-46.
56. Rehmatulla, N., Parker, S., Smith, T., Stulgis, V., 2017. Wind technologies: Opportunities and barriers to a low carbon shipping industry. *Marine Policy* 75, 217-226.
57. Ren, J., Fedele, A., Mason, M., Manzardo, A., Scipioni, A., 2013. Fuzzy multi-actor multi-criteria decision making for sustainability assessment of biomass-based technologies for hydrogen production. *International Journal of Hydrogen Energy* 38(22), 9111-9120.
58. Ren, J., Lützen, M., 2015. Fuzzy multi-criteria decision-making method for technology selection for emissions reduction from shipping under uncertainties. *Transportation Research Part D: Transport and Environment* 40, 43-60.
59. Ren, J., & Liang, H., 2017. Multi-criteria group decision-making based sustainability measurement of wastewater treatment processes. *Environmental Impact Assessment Review*, 65, 91-99.
60. Rogers, E.M., 2003. *The Diffusion Innovation 5th Edition*. Free Press, New York.
61. Rogers, E.M., 2010. *Diffusion of Innovations*. Simon and Schuster.
62. Roh, S., Thai, V.V., Wong, Y.D., 2016. Towards sustainable ASEAN port development: Challenges and opportunities for Vietnamese ports. *The Asian Journal of Shipping and Logistics* 32(2), 107-118.

63. Rungsithong, R., Meyer, K.E., Roath, A.S., 2017. Relational capabilities in Thai buyer-supplier relationships. *Journal of Business & Industrial Marketing* 32(8), 1228-1244.
64. Saaty, T.L., 1988. *Multicriteria Decision Making: The Analytic Hierarchy Process; Planning, Priority Setting, Resource Allocation*. McGraw-Hill.
65. Saaty, T.L., Vargas, L.G., 2012. *Models, Methods, Concepts & Applications of The Analytic Hierarchy Process*. Springer Science & Business Media.
66. Sahin, B., Yip, T.L., 2017. Shipping technology selection for dynamic capability based on improved Gaussian fuzzy AHP model. *Ocean Engineering* 136, 233-242.
67. Schaltegger, S., Hörisch, J., Freeman, R.E., 2017. Business cases for sustainability: a stakeholder theory perspective. *Organization & Environment*, 1086026617722882.
68. Schinas, O., Ross, H.H., Rossol, T.D., 2018. Financing green ships through export credit schemes. *Transportation Research Part D: Transport and Environment* 65, 300-311.
69. Shin, Y., Thai, V.V., Grewal, D., Kim, Y., 2017. Do corporate sustainable management activities improve customer satisfaction, word of mouth intention and repurchase intention? Empirical evidence from the shipping industry. *The International Journal of Logistics Management* 28(2), 555-570.
70. Sodhro, A. H., Pirbhulal, S., Luo, Z., & de Albuquerque, V. H. C. 2019a. Towards an optimal resource management for IoT based Green and sustainable smart cities. *Journal of Cleaner Production*, 220, 1167-1179.
71. Sodhro, A. H., Pirbhulal, S., & de Albuquerque, V. H. C. 2019b. Artificial intelligence driven mechanism for edge computing based industrial applications. *IEEE Transactions on Industrial Informatics.*
72. Sodhro, A. H., Malokani, A. S., Sodhro, G. H., Muzammal, M., & Zongwei, L. 2019c. An adaptive QoS computation for medical data processing in intelligent healthcare applications. *Neural Computing and Applications*, 1-12.
73. Sodhro, A. H., Shaikh, F. K., Pirbhulal, S., Lodro, M. M., & Shah, M. A. 2017a. Medical-QoS based telemedicine service selection using analytic hierarchy process. *In Handbook of Large-Scale Distributed Computing in Smart Healthcare,* pp. 589-609. Springer, Cham.
74. Sodhro, A. H., Li, Y., & Shah, M. A., 2017b. Green and friendly media transmission algorithms for wireless body sensor networks. *Multimedia Tools and Applications*, *76*(19), 20001-20025.
75. Sunderland, P.L., Denny, R.M., 2016. *Doing Anthropology in Consumer Research*. Routledge.
76. Tseng, M.-L., Wu, K.-J., Ma, L., Kuo, T.C., Sai, F., 2017. A hierarchical framework for assessing corporate sustainability performance using a hybrid fuzzy synthetic method-DEMATEL. *Technological Forecasting and Social Change*.
77. UNCTAD, 2017. Review of Maritime Transport
78. UNCTAD, 2018. Review of Maritime Transport.
79. Vagnani, G., Volpe, L., 2017. Innovation attributes and managers' decisions about the adoption of innovations in organizations: A meta-analytical review. *International Journal of Innovation Studies* 1(2), 107-133.
80. Van den Berg, R., De Langen, P.W., 2015. Assessing the intermodal value proposition of shipping lines: Attitudes of shippers and forwarders. *Maritime Economics & Logistics* 17(1), 32-51.

81. Vejvar, M., Lai, K.-h., Lo, C.K.Y., Fürst, E.W.M., 2017. Strategic responses to institutional forces pressuring sustainability practice adoption: Case-based evidence from inland port operations. *Transportation Research Part D: Transport and Environment*.
82. Wang, X., Yuen, K.F., Wong, Y.D., Teo, C.C., 2018. An innovation diffusion perspective of e-consumers' initial adoption of self-collection service via automated parcel station. *The International Journal of Logistics Management* 29(1), 237-260.
83. Yeh, C.-C., Xing, M.-H., 2016. Key factors influencing digital content industry in Taiwan from the triple helix perspective. *Technology Analysis & Strategic Management* 28(6), 691-702.
84. Yang, C.-S., 2018. An analysis of institutional pressures, green supply chain management, and green performance in the container shipping context. *Transportation Research Part D: Transport and Environment* 61, 246-260.
85. Yuen, K.F., Thai, V., 2017. Barriers to supply chain integration in the maritime logistics industry. *Maritime Economics & Logistics* 19(3), 551-572.
86. Yuen, K.F., Thai, V.V., Wong, Y.D., 2016a. Are customers willing to pay for corporate social responsibility? A study of individual-specific mediators. *Total Quality Management & Business Excellence* 27(7-8), 912-926.
87. Yuen, K.F., Thai, V.V., Wong, Y.D., 2016b. The effect of continuous improvement capacity on the relationship between of corporate social performance and business performance in maritime transport in Singapore. *Transportation Research Part E: Logistics and Transportation Review* 95, 62-75.
88. Yuen, K.F., Thai, V.V., Wong, Y.D., 2017a. Corporate social responsibility and classical competitive strategies of maritime transport firms: A contingency-fit perspective. *Transportation Research Part A: Policy and Practice* 98, 1-13.
89. Yuen, K.F., Wang, X., Ma, F., Lee, G., Li, X., 2019a. Critical success factors of supply chain integration in container shipping: An application of resource-based view theory. *Maritime Policy & Management*, 1-16.
90. Yuen, K.F., Wang, X., Ng, L.T.W., Wong, Y.D., 2018a. An investigation of customers' intention to use self-collection services for last-mile delivery. *Transport Policy* 66, 1-8.
91. Yuen, K.F., Wang, X., Wong, Y.D., Ma, F., 2019b. A contingency view of the effects of sustainable shipping exploitation and exploration on business performance. *Transport Policy*.
92. Yuen, K.F., Wang, X., Wong, Y.D., Zhou, Q., 2017b. Antecedents and outcomes of sustainable shipping practices: The integration of stakeholder and behavioural theories. *Transportation Research Part E: Logistics and Transportation Review* 108, 18-35.
93. Yuen, K.F., Wang, X., Wong, Y.D., Zhou, Q., 2018b. The effect of sustainable shipping practices on shippers' loyalty: The mediating role of perceived value, trust and transaction cost. *Transportation Research Part E: Logistics and Transportation Review* 116, 123-135.
94. Zadeh, L.A., 1965. Fuzzy sets. *Information and Control* 8(3), 338-353.
95. Zhang, L., Wang, J., 2018. Research on the relationship between relational capital and relational rent. *Cogent Economics & Finance* 6(1), 1431091.

APPENDIX

Table A1: Key CSFs and sub-criteria for sustainable shipping management

Key criteria/ sub-criteria	Description	Sources
A. Stakeholders' focus	Reflecting stakeholders' economic, social, and environmental requirements in sustainability management	Pagell and Shevchenko (2014); Lai et al. (2013); Freeman (2010)
A1. Shareholders' focus	Reflecting shareholders' economic, social, and environmental requirements in sustainability management	Giannakopoulou et al. (2016); Schaltegger et al. (2017); Yuen et al. (2017a); Parviainen et al. (2018)
A2. Vendors' focus	Reflecting vendors' economic, social, and environmental requirements in sustainability management	Schaltegger et al. (2017); Shin et al. (2017); Van den Berg and De Langen (2015); Yuen et al. (2016a, 2017a)
A3. Shippers' focus	Reflecting shippers' economic, social, and environmental requirements in sustainability management	Van den Berg and De Langen (2015); Yuen et al. (2016a); Freudenreich et al. (2019); Octaviannand et al. (2017); Pang and Lu (2018); Shin et al. (2017)
A4. Employees' focus	Reflecting employees' economic, social, and environmental requirements in sustainability management	Octaviannand et al. (2017); Pang and Lu (2018); Bocken et al. (2013); Freudenreich et al. (2019); Joyce and Paquin (2016); Yuen et al. (2017a)
A5. Society's focus	Reflecting the society's economic, social, and environmental requirements in sustainability management	Bocken et al. (2013); Joyce and Paquin (2016); Yuen et al. (2017a)

B. Intra-firm management	Focusing on the internal resources of a shipping company to manage sustainability	Jensen et al. (2016)
B1. Physical assets	Investing in eco-friendly assets such as green buildings and equipment, vessels, and trucks to manage sustainability	Schinas et al. (2018)
B2. Financial resources	Dedicating sufficient financial capital to manage sustainability	Progoulaki and Roe (2011); Busby (2019)
B3. Sustainable knowledge	Focusing on knowledge building to improve current sustainability processes and explore innovative ways to manage sustainability	Durst and Runar Edvardsson (2012);Yuen et al. (2019a); Yuen et al. (2019b)
B4. Organisational culture	Espousing the support for sustainability in the vision, mission, goals, and objectives of the company or via communication from the management	Sunderland and Denny (2016)
C. Inter-firm collaboration	Focusing on collaboration with partners to manage sustainability	Dyer et al. (2018)
C1. Inter-firm relationship management	Focusing on relationship management and marketing such as building trust with partners to manage sustainability	Yuen et al. (2018b); Child et al. (2019)
C2. Inter-firm knowledge sharing	Organising regular conferences, meetings, and workshops with partners to share the best practices and knowledge to manage sustainability	Cross et al. (2001); Lee and Nam (2017); Dyer et al. (2018)
C3. Complementary resources/capabilities	Pooling and sharing of financial, equipment, and labour resources to manage sustainability (e.g. forming of sustainability task force, joint investments in research and development on ship or port technologies, and implementing cold-ironing)	Chin et al. (2015); Ling-Chin and Roskilly (2016); (Yuen et al., 2017a); Rungsithong et al. (2017)
C4. Effective governance mechanisms	Developing tighter contractual agreements with partners to comply with regulations and create mutual goals and policies to manage sustainability	Duschek (2004); Roh et al. (2016); Zhang and Wang (2018)
D. New technology acceptance	Encouraging employees to accept the adoption of new technologies to manage sustainability	Sahin and Yip (2017); Wang et al. (2018); Yuen et al. (2018a)

D1. Relative advantage	Evaluating the alternatives and selecting technologies that confer the optimum economic, social, and environmental benefit to manage sustainability	Yuen et al. (2018a)
D2. Compatibility	Evaluating the scalability and integrability of new technologies with existing technologies, business processes, and systems prior to procuring the new technologies to manage sustainability	Rogers (2003); Rogers (2010); Vagnani and Volpe (2017)
D3. Complexity reduction	Simplifying the use of technologies and providing training for employees to encourage their adoption to manage sustainability	Rogers (2010); Wang et al. (2018)
D4. Trialability	Implementing trials for new technologies before their full adoption to allow employees to detect errors and improve their familiarity with using the technologies to manage sustainability	Rehmatulla et al. (2017); Wang et al. (2018)
D5. Observability	Selecting technologies with processes and results that can be easily learned or related by employees to manage sustainability	Hashem and Tann (2007); Vagnani and Volpe (2017)
E. Strategic fit	Ensuring the relevancy of the management of sustainability with the strategy of the company	Donaldson (2001); Yuen et al. (2019b)
E1. Fit with strategic intention	Tying the company's sustainability activities with the aim of making profits	Yuen et al. (2016a); Yuen et al. (2017b); Yuen and Thai (2017)
E2. Fit with competitive strategies	Identifying the company's competitive strategy (e.g. low-cost or differentiation) and implementing SSM activities that complement the competitive strategy	Yuen et al. (2017a); Liu and Atuahene-Gima (2018); Lam and Wong (2018)

TABLES

Table 1. The triangular fuzzy number and linguistic term.

Fuzzy number	Linguistic term	Triangular fuzzy number
1	Equally important	(1,1,3)
3	Moderately important	(1,3,5)
5	Strongly important	(3,5,7)
7	Very strongly important	(5,7,9)
9	Extremely strongly important	(7,9,9)

Source: Nurani et al. (2017)

Table 2. The random consistency index.

Size (n)	1	2	3	4	5	6	7	8
RI	0	0	0.52	0.89	1.11	1.25	1.35	1.40

RI, random index

Source: Saaty (1988)

Table 3. Respondents' profile.

Demographic	Range	Number	Percentage (%)
Position	Deputy division manager	6	16.67
	Division manager	12	33.33
	Branch manager	14	38.89
	Director	4	11.11
Age (years)	Under 30	6	16.67
	30–40	16	44.44
	40–50	12	33.33
	Above 50	2	5.56

Firm size (number of employees)	Below 50	10	27.78
	51–100	14	38.89
	101–150	6	16.67
	151–200	4	11.11
	Over 200	2	5.56
Sector	Dry or liquid bulk	14	38.89
	Container	22	61.11

Table 4. Analysis results of the fuzzy analytic hierarchy process.

Key criteria	Local weights	Consistency rate	Sub-criteria	Local weights	Local rank	Global weights	Global rank
Stakeholders' focus	0.298 [1st]	0.022	Shareholders' focus	0.300	1	0.089	2
			Vendors' focus	0.243	2	0.072	5
			Shippers' focus	0.147	4	0.044	12
			Employees' focus	0.134	5	0.040	13
			Society's focus	0.175	3	0.052	8
Intra-firm management	0.248 [2nd]	0.028	Physical assets	0.317	2	0.079	3
			Financial resource	0.376	1	0.093	1
			Sustainable knowledge	0.189	3	0.047	10
			Organisational culture	0.118	4	0.029	16
New technology acceptance	0.156 [3rd]	0.009	Relative advantage	0.296	1	0.046	11
			Compatibility	0.18	3	0.028	17
			Complexity reduction	0.199	2	0.031	15
			Trialability	0.152	5	0.024	19
			Observability	0.173	4	0.027	18
Inter-firm collaboration	0.154 [4th]	0.037	Inter-firm relationship management	0.326	2	0.050	9
			Inter-firm knowledge sharing	0.344	1	0.053	7

			Complementary resources and capabilities	0.211	3	0.032	14
			Effective governance mechanisms	0.120	4	0.018	20
Strategic fit	0.143 [5th]	0.035	Strategic intention	0.481	2	0.069	6
			Competitive strategies	0.519	1	0.074	4

FIGURES

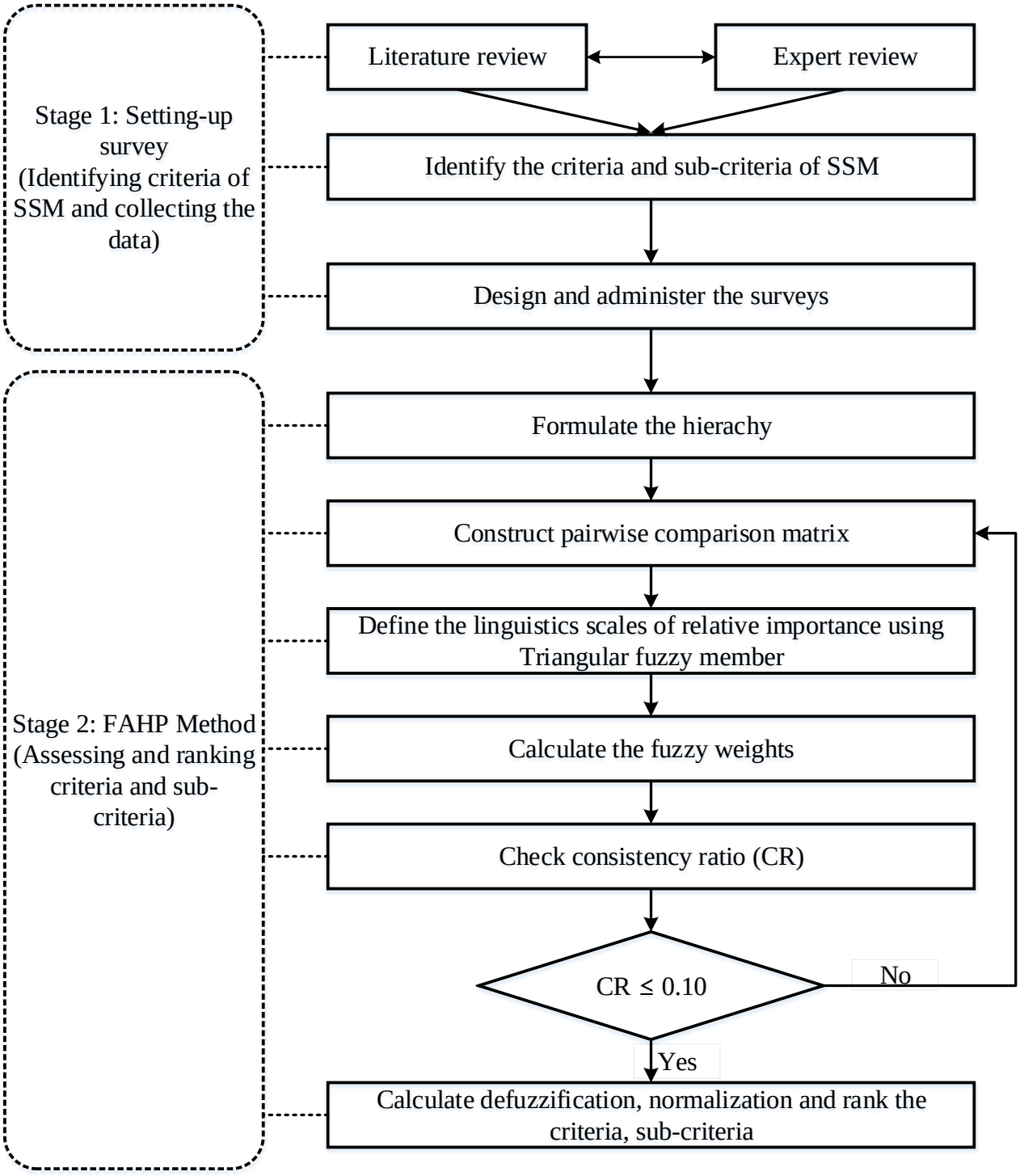

Fig. 1. The process of methodology.

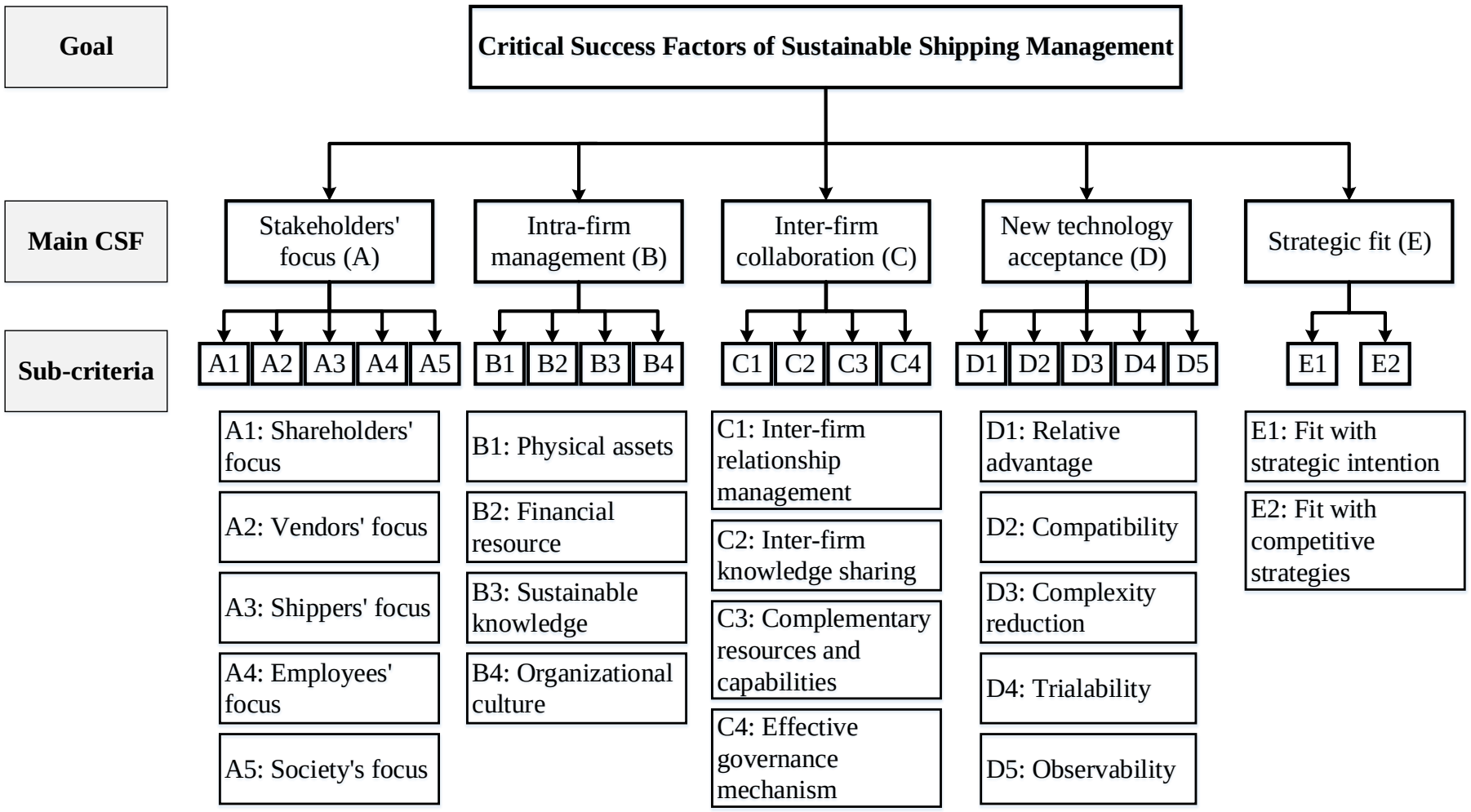

Fig. 2. The hierarchical model.

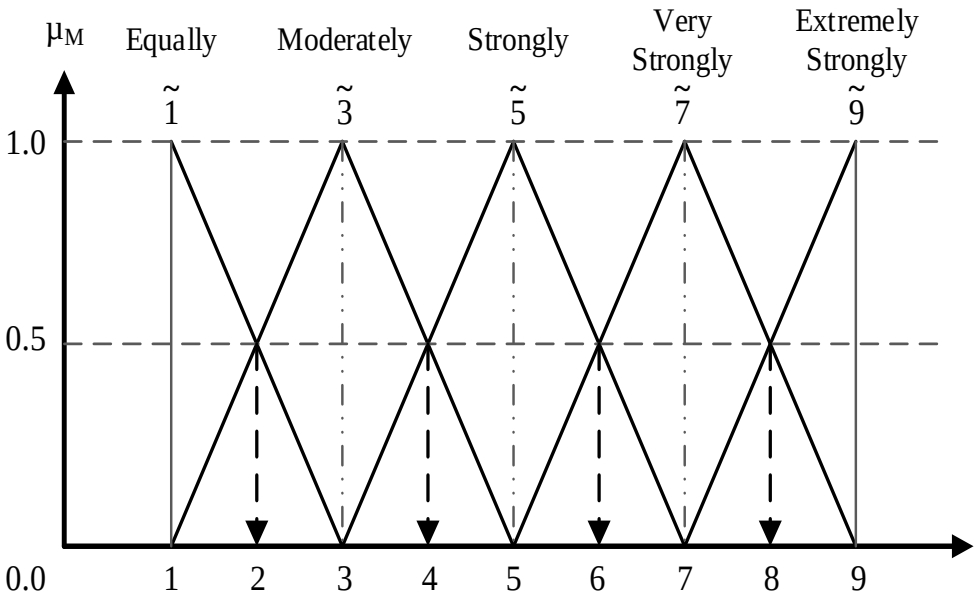

Fig. 3. Fuzzy membership function for the linguistic expressions for key CSFs and sub-criteria.